Concept Demonstration of Dopant Selective Reactive Ion Etching in SiC

Principal Investigator: Dr. Robert S. Okojie (PI)/LCS at NASA GRC,

Co-Investigators: Dr. Robert Shinavski (Rolls-Royce), Dr. Ender Savrun (Sienna Technologies)

Abstract:

Accurate quantification of combustor pressure dynamics for the primary purpose of experimental validation of computational fluid dynamics (CFD) codes requires the use of robust, reliable and sensitive pressure sensors that can resolve sub-psi pressure levels in high temperature environments (i.e., combustor). The state of the art microfabricated piezoresistive silicon carbide (SiC) pressure sensors that we have developed is capable of operating reliably at 600 ºC. This technology was used in support of the ARMD ISRP-ERA program to quantify combustor thermoacoustic instabilities. The results showed that while the SiC pressure sensors survived the high temperature and measured instabilities, the diaphragm (force collector) was not thin enough to be sensitive in resolving sub-psi pressures; 30 μm is the thinnest diaphragm achievable with conventional reactive ion etching (RIE) processes. Therefore, this precludes its use for sub-psi pressure measurement with high fidelity. In order to effectively resolve sub-psi pressures, a thinner more sensitive diaphragm (< 10 μm) is needed. To achieve this would require a new and innovative fabrication process technique.

During the RIE process experiments to obtain thinner diaphragms, SiC etch rates were observed to be influenced by the dopant concentration and whether it is n- or p-type. This observed Dopant Selective Reactive Ion Etching (DSRIE) in SiC provided a potentially new technique for the fabrication of ultra-thin (~2 μm) planar and 3-D structures for application in new and emerging sensor technologies.

In Phase I of the work, the chemistry-physics of SiC-DSRIE was experimentally investigated in terms of the relationship between dopant concentration and reactivity in a fluorine-based (SF_6) plasma. From the preliminary results, it was observed that, for the two n-type conductivities investigated, the etch rate decreased with increasing dopant concentration. Evidence of etch selectivity was also observed between n-type and p-type SiC. In this case, highly doped p-type SiC was found to have higher etch rates than n-type conductivity of certain dopant concentration.

Phase II focused on two main objectives. One was to expand the DSRIE investigation to other gaseous halides, such as BCl_3, HBr, and Cl_2, with the main goal of increasing etch selectivity. The results from the experiments led to the realization of 1-3 µm thin diaphragms. They will be used to attempt the implementation of the second objective, which is to fabricate and test sub-psi resolution (<1 psi) SiC pressure sensors for the first time.